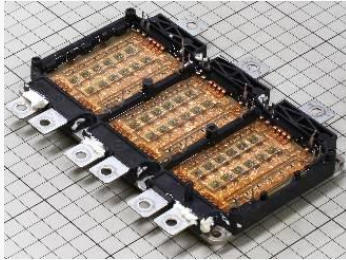
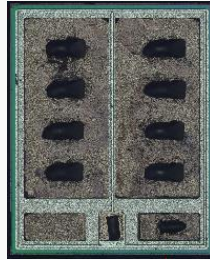


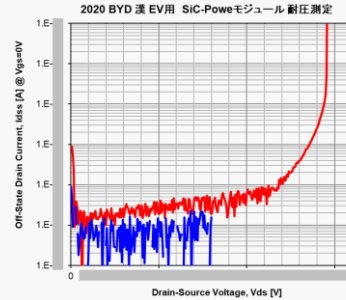
BYD Han EV (2020) rear inverter SiC power module: Structure analysis and MOSFET process analysis reports



Module appearance



SiC MOSFET Die



SiC MOSFET Idss-vs-Vds

Product Summary

Model number: BM840F12B34U2 3-Phase Motor Inverter Module

- In-vehicle SiC power module used for the first time in the rear inverter of BYD Han EV (released in China in July 2020)
- Inverter specifications: Maximum output 200kW, Rated voltage: 570V, Current: 420Arms
- Die size: 4.32 mm x 5.32 mm, Trench type MOSFET

Reports Content

◆ SiC power module structure analysis report. [Report price: US\\$7,500 \(100 pages\)](#)

1. BYD's in-vehicle module that uses single-sided cooling (PinFin).
 - * Sintered Ag is used for the die attach between the die and the module electrode.
2. Adopted a multi-die configuration using 6 MOSFETs per 1 switch.
 - * Possible countermeasure against low manufacturing yield ?
3. The SiC- MOSFET uses a trench gate structure.

◆ SiC MOSFET process analysis report. [Report price: US\\$7,500 \(35 pages\)](#)

1. Conducted electrical characteristics (static characteristics) evaluation.
 - * The maximum operating voltage of this product is 1200V.
 - * This MOSFET features the lowest Idss compared with others SiC devices.
 - * Specific RonA is about the same as the 3rd gen SiC MOSFETs of major manufacturers (INFINEON etc.)
2. Estimate the impurity concentration of the N-Epi layer and analysis of the ON resistance components from the structure and electrical evaluation.
3. Considerations of particular structural features.
 - Extraction of manufacturing process flow and estimation of the number of masks.

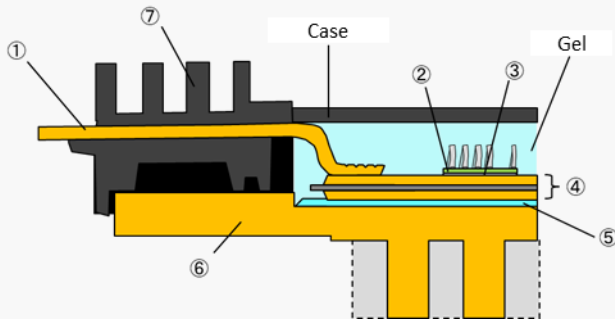
Note: The report price may change over time. For current price contact info@ltecusa.com.

Excerpt from SiC Power Module Structural Analysis Report (1)

Content

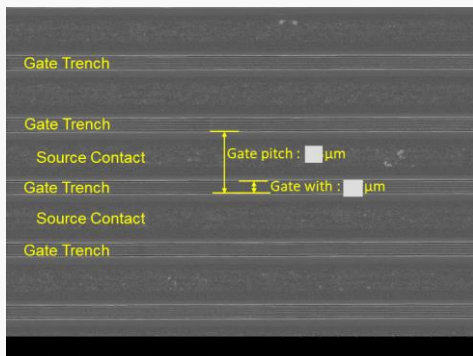
		Page
1. Device summary	...	3
1-1. Summary of analysis results	...	4
2. Module structural analysis		
2-1. Module appearance	...	9
2-2. Module observation	...	12
2-3. Observation of mounted dies	...	17
2-4. Module cross-sectional observation	...	18
3. SiC-MOSFET structural analysis		
3-1. Plane structure analysis (OM)	...	47
3-2. Plane structure analysis (SEM)	...	67
3-3. Transistor cell area cross-sectional analysis	...	79
3-4. Peripheral area cross-sectional analysis	...	85
3-5. Gate electrode wiring section cross-sectional structure analysis	...	95

Excerpt from SiC Power Module Structural Analysis Report (2)

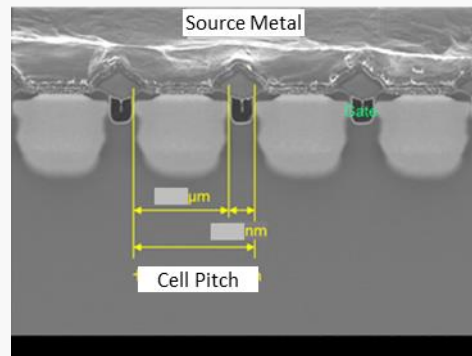


Module structure schematic diagram

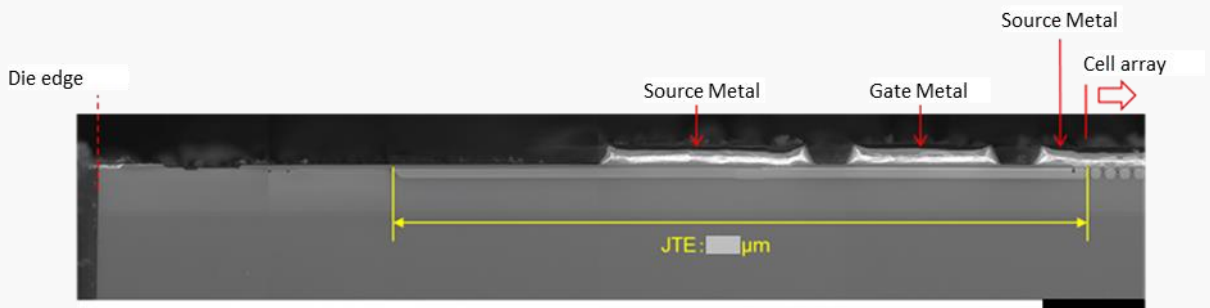
#	Measured Part	Thickness	Material
1	Terminal	1010 μ m	Cu
2	SiC-MOSFET		
2-1	Bonding wires (Source)		
2-2	Bonding wires (Gate)		
2-3	Top surface protection film		
2-4	Top surface metal		
2-5	Semiconductor substrate		
2-6	Backside metal-1		
2-7	Backside metal-2		
2-8	Backside metal-3		
2-9	Backside metal-4		
3	Die Attach		
4	AMC Power substrate		
4-1	AMC Upper metal		
4-2	Dielectric		
4-3	AMC Lower metal		
5	Solder		
6	Heat Cooler		
6-1	Ni plated layer		
6-2	Base plate		
6-3	Heat sink Pin length		
7	Case	-	C,Si,O,Mg,Al,Sb,Ca,S



Cell array plane SEM image (Poly-Si layer)



Transistor Cell array SEM image



Cross-section SEM image of the outer periphery of the die.

Excerpt from SiC MOSFET Process Analysis Report (1)

	Content	Page
1	BYD's SiC MOSFET for Han EV Motor Inverter Summary of analysis results	3
1-1	Comparison of BYD and other companies' SiC- MOSFETs	4
1-2	SiC MOSFET die	5
1-3	Die edge	6
1-4	Device structure: SiC-MOSFET	8
	Transistor schematic cross section	9
2	SiC-MOSFET Observation	11
2-1	Transistor structure and process features (1)-(4)	11
3	BYD's SiC MOSFET analysis result	15
	Table 1 Device structure: SiC-MOSFET	15
	Table 2 SiC-MOSFET : Layer material and thickness	16
4	Process flow	17
4-1	SiC MOSFET Front-End Wafer Process Flow (Estimated)	17
4-2	SiC- MOSFET process sequence cross-section schematics	18
5	Electrical characterization	24
5-1	BYD's SiC MOSFET Id-Vds characteristics	25
5.2	ON resistance RON temperature dependence	26
5-3	Off-state Drain current Idss vs. drain voltage (Vds) with device temperature as parameters, and activation energy (Ea)	27
5-4	Off-state breakdown voltage BVdss	28
5-5	Comparison of leak currents Idss between manufacturers	29
5-6	Capacitances (Ciss, Coss, Crss)-Vds characteristics	30
5-7	SiC-MOSFET Body-Diode characteristics	31
5-8	Device structure and electrical characteristics analysis: ON resistance	32
5-9	N-Epi layer impurity concentration analysis	34
5-10	Device structure and electrical characteristics analysis: Breakdown voltage	35

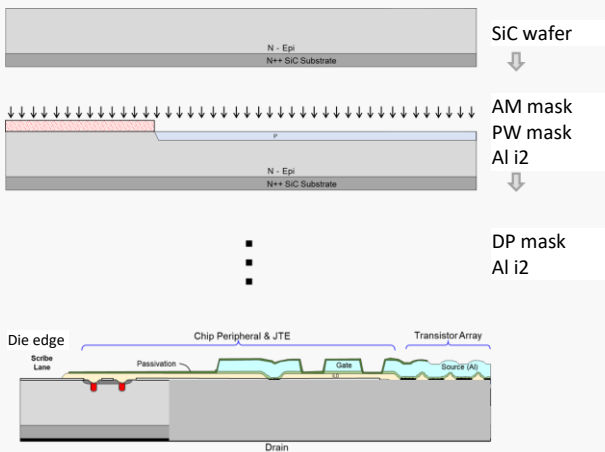
Excerpt from SiC MOSFET Process Analysis Report (2)

1-1. Comparison of BYD and other companies' SiC- MOSFETs

Maker	Part no.	Process Gen	Production	Vdss [V]	RON [mΩ]	Die Size [mm x mm]	Die Area [mm ²]	Intrinsic RONxA [mΩ·mm ²]
ROHM	SCT3080KL/HR	Gen 3	2016	1200	80	3.01x2.41	7.3	408
WOLFSPEED (CREE)	C3M0075120K	Gen 3	2017					
ON-SEMI	NVHL080N120SC1	Gen 1	2018					
INFINEON	FF11MR12W1M1_B1 IMW120R045M1	Gen 1	2017					
MICROSEMI	APT80SM120B	Gen 1						
MICROSEMI	MSC040SMA120B	Gen 2	2018					
LITTELFUSE	LSICM0120E0080	-	2017					
TOSHIBA	TW070J120B	Gen 1 *	2020					
DENSO	Toyota MIRAI FEC EV	Gen 1	2021					
BYD(?)	BYD's Han EV	—	2020					

*) With built-in Schottky Barrier Diode (SBD)

Manufacturing process flow



Electrical characterization

